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THE POSITION OF THE CENTER OF THE MASS FROM THE KNEE CENTER CORRELATES CLOSELY WITH THE KNEE ADDUCTION MOMENT IN PATIENTS WITH KNEE OSTEOARTHRITIS

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Purpose: The external knee adduction moment (KAM) has been demonstrated to be a risk factor for the progression of knee osteoarthritis. The KAM can be changed by the relative position of the knee center, the center of pressure (COP), and the center of the mass (COM) during walking. Few previous gait analysis studies have examined whether the distance from the COM to the knee center are variables that influence the KAM or its relationship with the kinematics of the trunk and lower limbs. Therefore, the objective of this study was to clarify the relationships among the KAM, COM and other kinematic variables.

Methods: Nineteen subjects with knee osteoarthritis, eighteen females and one male, with an average age of 70.9 years (range: 50- 79 years) were recruited from the university hospital. The study was approved by the institutional board, and all subjects gave their written informed consent for their participation. All subjects had a radiograph taken while standing on one foot. The femorotibial joint in all radiographs was evaluated using the Kellgren and Lawrence scale (K/L). Two subjects had a K/L score of 2, nine had a K/L of 3, five had a K/L of 4. The knees with more symptoms were investigated. The average femorotibial angle (FTA) was 178.9° (range: 174°-187°).

Gait data were collected with a six camera motion analysis system and two force plates that were time synchronized and sampled at 120 Hz and 1200 Hz, respectively. Modified Helen Hays marker sets with 31 retroreflective markers were attached.

The subjects were instructed to walk on a 10 m walkway at a self-selected speed. A total of three trials with clean, single force plate strikes from the study limb were collected. The external first peak knee adduction moment in the stance phase (1st KAM), COM, the distance from the COM to the center of the knee in the frontal plane (COM-K), lateral trunk tilt, lateral pelvic tilt, adduction angle at the hip joints, toe-out angle of the foot, gait width and the gait speed were analyzed.

The external moment was calculated with OrthoTrak. The kinetic data were calculated using the Matlab R2009b software program. All angles were reported during the stance phase of the gait for the affected limb at the first peak knee adduction moment. Values for each gait variable were obtained by averaging them across the trials.

We used Pearson correlation coefficients to examine the relationships among the 1st KAM, FTA, COM-K, trunk tilt angle, pelvic tilt angle, hip adduction angle, leg heel angle, heel floor angle and toe-out angle. We used a multiple regression analysis to evaluate the amount of variance in the 1st KAM explained by FTA, COM-K, pelvic tilt angle and toe-out angle.

Results: The 1st KAM was significantly correlated with the COM-K ($r=0.64$, $p=0.014$) and the pelvic tilt angle ($r=-0.458$, $p=0.043$). The COM-K was also significantly correlated with the trunk tilt angle ($r=-0.46$, $p=0.040$) and hip adductor angle ($r=-0.60$, $p=0.005$).

In a multiple regression analysis, the COM-K and pelvic tilt angle were independently correlated with the 1st KAM ($R2 = 0.445$).

Conclusions: The 1st KAM was more closely correlated with the COM-K than with the foot-related variables. Modifications to the position of the COM, including the pelvic tilt, trunk tilt, and hip adduction are important to reduce the 1st KAM for patients with knee osteoarthritis.

The factors associated with the 1st knee adduction moment as determined by a multivariate analysis.

Predictor variables	β-coefficient	Standard error	p value
COM-K	0.0050	0.002	0.006
Pelvic tilt	0.042	0.015	0.014
Femorotibial angle	-0.011	0.009	0.232
Toe-out angle	0.009	0.006	0.133

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CHANGES TO ROTATIONAL LOADING AFTER ACL INJURY AND RECONSTRUCTION DURING STANDING TARGET MATCHING

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Purpose: Nearly half of patients with anterior cruciate ligament injury will eventually get osteoarthritis (OA). Frontal plane knee measures are commonly used to explain the high incidence of OA but rotational loading may also be a contributing factor. Transverse knee moment (TKM) can help understand rotational instability common after ACL injury and correlates to cartilage loss. Measuring transverse knee moment during tasks that require dynamic rotational loading, such as a run cut maneuver, post ACL injury and reconstruction risks re-injury. Our lab uses a standing target matching protocol that safely evaluates rotational loading as it requires sub-maximal forces. In standing target matching subjects generate controlled shear forces to control a cursor. Our goal was to use standing target matching to understand rotational loading in ACL deficient (ACL-d) and reconstructed (ACL-r) subjects. We hypothesized that TKM measured during standing target matching would be greater in ACL-d subjects than healthy subjects and similar between healthy and ACL-r subjects.

Methods: This study included 8 healthy, 8 ACL-d and 8 ACL-r subjects, all of similar age, mass and BMI. Reconstruction types included cadaveric allograft or hamstrings autograft. ACL-d subjects were tested within 6 months of injury. ACL-r subjects were tested 6 months to 1 year of surgery.

For the standing target matching subjects stood barefoot on 2 force plates (OR-6 AMTI, Watertown, MA, USA), each limb on a force plate. Subjects controlled a cursor presented on a screen in front of them. The cursor was controlled by shear forces generated by a single limb. The goal of standing target matching was to create the forces to place the cursor on a location on the screen designated with a target. Shear direction controlled the cursor's movement in that direction if subjects created shear in the anterior/posterior direction the cursor moved towards the top/bottom of the screen, respectively, and AP shear forces moved the cursor left and right. 18 targets were presented at 20° increments around a circle; target position order was randomized. Target position from the center of the screen was 50% of the minimum shear MVC of the anterior, posterior, medial, and lateral directions. Cursor size was based on weight distribution; requiring even distribution of body weight. Standard motion capture techniques were used to collect kinematic and GRF data during target matching.

Results: ACL-d and ACL-r limbs have significantly larger TKM when compared to limbs of healthy subjects when matching targets (Figure 1). The ACL-d limbs have greater internal rotation moment (designated as a positive TKM) at 5 target positions which require medial shear forces (140°-220°).

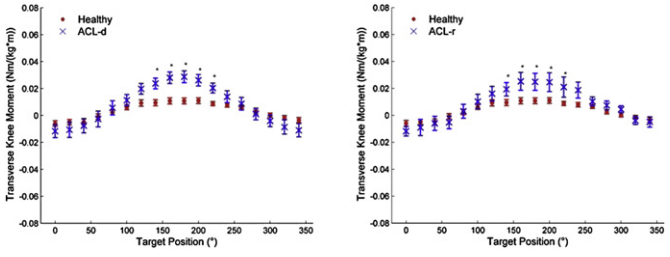

Figure 1. Avg. TKM ± SE normalized to mass*height: ACL-d (left), ACL-r (right) & healthy subjects. * $p<0.05$.

Conclusion: ACL-d patients have increased TKM which persists after reconstruction. These findings support our first hypothesis but do not support our second hypothesis. Increased moments occur at target positions requiring medial shear force. Previous research using standing target matching found poor muscular control post injury. After injury there is poor proprioception in transverse and sagittal planes. Poor control and reduced proprioception are creating increased rotational loading which presents itself strongly at medial target positions. Higher rotational loading occurs at medial target positions; producing medial shear force may be dangerous when patients return to sport. Athletes experience medial shear force multiple times during a single game which also contributes to valgus collapse, a contributor to noncontact

ACL injury. Overall, those with ACL injury and reconstruction have poor motor control leading to increased rotational loading, a contributing factor to OA. The coupling of medial shear force and valgus collapse put patients at risk for re-injury and results in increased TKM that contribute to OA progression.

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COMPARISON OF ISOLATED AND COMBINED ORTHOTIC DEVICES ON KNEE LOADING WHILST ASCENDING STAIRS IN PATIENTS WITH MEDIAL KNEE OSTEOARTHRITIS

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Purpose: Valgus knee braces and lateral wedged insoles are common modalities used in the treatment of medial tibiofemoral osteoarthritis (OA) of the knee joint. Both treatments have been shown to reduce the external knee adduction moment (EKAM) during walking conditions, and more recently during stair ascent and descent. There is evidence suggesting that combining these treatments during walking tasks (by altering the position of the knee joint centre with the knee brace and the orientation of the ground reaction force with a lateral wedge insole) produced a greater overall reduction of the EKAM. Stair ascent is a common and frequent activity in daily living and demands, compared to walking on level ground, a greater range of motion and around six times more load on the knee joint. Therefore, determining whether insoles, braces or a combined approach reduces loads in patients with medial knee OA is warranted. The hypothesis of this study was that a combined orthotic management of a valgus knee brace and lateral wedged insole was better at reducing EKAM than the single treatments alone.
Methods: Participants underwent a 3D kinematic (Qualysis OQUS, Gothenburg, Sweden) and kinetic (AMTI, USA) analysis whilst ascending three stairs in a control shoe, an off-the-shelf lateral wedge insole (Salford Lateral Wedge) inserted bilaterally into the control shoe, an off-the-shelf Ossur UnloaderOne valgus knee brace, both the lateral wedge insole and valgus knee brace combined, in a randomised order. During trials, lateral wedge insoles were inserted into the control shoes and were worn bilaterally and trials were fully randomised with a minimum of three trials per condition. The EKAM was calculated and exported during single support only as this is the phase of the stair cycle where loading is at its maximum. Peak early-single support (0-33%) EKAM; peak mid-single support (34-66%) EKAM; and peak late-single support (67-100) EKAM were extracted along with the knee adduction angular impulse (KAAI) for support phase only. A repeated measures of analysis of variance was undertaken to determine any significant differences at the 95% Confidence interval ($p<0.05$) between the control shoe and the orthotic conditions.
Results: Seven participants (5 female, 2 male) were radiographically confirmed with medial knee OA. The combination of the valgus knee brace and lateral wedged insole significantly reduced the early-single support EKAM ($p = 0.04$) compared to the control shoe. However, during mid-single support only the lateral wedged insole reduced EKAM was significantly different ($p =0.004$) to the control shoe. During late-single support the lateral wedged insole and the combined valgus brace and lateral wedged insole reduced the EKAM significantly in comparison to the control shoe ($p = 0.021$ and $p = 0.033$ respectively), with the combined valgus knee brace and lateral wedged insole reducing EKAM significantly in comparison to the valgus knee brace alone ($p=0.046$). The KAAI was significantly reduced for the insole ($p = 0.003$) and the combined lateral wedged and valgus knee brace ($p = 0.008$), with the valgus knee brace bordering significance ($p=0.054$) in comparison to the control shoe.
Conclusions: Our findings demonstrate that using a combination of an off-the-shelf valgus knee brace and off-the-shelf lateral wedge insole significantly reduces knee loading during stair ascent, during early- and late-single support in comparison to a control shoe. However, it was only during late-single support where the combination was significantly different to the orthotic treatments alone. This initial study supports previous literature on custom designed braces and insoles. Given that adherence to valgus knee braces is a challenge, one potential outcome of this study would be for an individual to wear a lateral wedged insole and use the valgus knee brace at times of heavy activities during the day. Future research investigating beneficial clinical effects are needed.

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FUNCTIONAL RECOVERY AFTER TOTAL JOINT REPLACEMENT IN HIP OSTEOARTHRITIS: COMPARISON BETWEEN ANTEROLATERAL MINI-INVASIVE VERSUS POSTERIOR APPROACH

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Purposes. One of the difficulties in evaluating functional recovery after total hip replacement (THR) in hip osteoarthritis lies in the fact that surgical assessment is mostly subjective. The aim of the study was to compare functional recovery after THR according to two different surgical approaches not only from a conventional clinical perspective but also with regard to a quantified gait analysis.
Methods. Prospective pilot study comparing two THR approaches at short and medium terms: mini-invasive antero-lateral Rottinger approach vs. posterior 'Moore' approach in 25 patients suffering from hip osteoarthritis. Functional evaluation were performed using WOMAC questionnaire, Harris Hip Score and the Postel Merle d'Aubigne scores and 3D gait analysis including standard gait parameters, hip kinematics angles and postural analysis.
Results. The effect size (>1) was high for both surgical approaches but statistically greater improvement in PMA was noted at D45 and D180 in favour of the RoA group. The 3D gait analysis at D180 did not reveal any difference between groups for the standard gait parameters. All of the patients had significantly increased their gait speed at 6 months (v0.9 m/s after THR). This improvement was induced by increased stride length, since step frequency was identical (data not shown). The only significant difference between groups for kinematics angles was greater hip abduction in the MoA group at 6 months ($p= 0.024$), which was not noted at baseline ($p=0.14$). Maximal hip extension seemed to be greater in both groups after THR, but the difference did not reach statistical significance. . A greater improvement in postural stability was also detected in this group .
Conclusion. This study is the first to compare two specific references surgical approaches in term of functional recovery using validated subjective questionnaires and innovative 3D gait parameters. These results suggested that the Rottinger approach procured in terms of effect size faster clinical recovery than the Moore approach and better postural stability at 6 months for hip osteoarthritis patients. This postural gain might be explained by better preservation of the muscles involved in the pelvis stability in the standing position.

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TOTAL HIP REPLACEMENT NONRESPONDERS WITH HIGH BASELINE CLINICAL SCORES HAVE SIMILAR GAIT IMPAIRMENT AS THOSE WITH LOW BASELINE CLINICAL SCORES

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Purpose: It is known that not all patients respond to total hip replacement (THR). We recently reported significant gait impairment in THR nonresponders compared to responders, but also noted considerable variability in the nonresponders' preoperative clinical scores. Preoperative scores indicated that some nonresponders were apparently quite well-functioning even before THR; in these cases the importance of a nonresponder designation is unclear. The purpose of this study was to investigate whether or not there are objective functional differences, measurable through gait analysis, between THR nonresponders with high vs. low preoperative clinical scores.
Methods: We used an IRB-approved repository to identify subjects with gait data and Harris Hip Scores (HHS) that was collected before primary unilateral THR and $\geq$ 6 months postoperatively (mean follow-up 15$\pm$9 mos). At each visit, 2-8 gait trials were collected at a range of self-selected walking speeds. Our variables of interest here were the walking speed, dynamic sagittal plane hip range of motion and the peak external moments in the sagittal, frontal, and transverse planes at each subject's normal speed. We adapted OMERACT-OARSI response criteria for use with the HHS, using published data comparing HHS and WOMAC properties, then used these criteria to identify responders and nonresponders. As previously reported, 18 of the 128 THR subjects identified were nonresponders. We formed two groups of nonresponders based on whether or not each subject's preoperative HHS was $\geq$ 80. This score is typically considered to represent a "good" postoperative outcome. We used t-tests to compare gait variables before and after surgery for the two groups.